

CLAIMS

What is claimed is:

1 1. A capillary pump loop (CPL) cooling system, comprising:
2 a first evaporator, adapted to be thermally coupled to a first semiconductor heat
3 source, including a cavity in which a working fluid is evaporated from a liquid state into a
4 vapor state and having a liquid inlet port to receive the working fluid in a liquid state and a
5 vapor outlet port from which the working fluid exits the evaporator in a vapor state;
6 a first wicking structure, having an input side to receive the working fluid in a liquid
7 state and including a plurality of capillary channels to draw the working fluid into the
8 evaporator through a capillary transport mechanism;
9 a first condenser to condense the working fluid from a vapor state into a liquid state,
10 having a vapor inlet port to receive the working fluid in its vapor state and a liquid outlet port
11 from which the working fluid exits the condenser in its liquid state;
12 a vapor transport line operatively coupling the vapor output port of the evaporator to
13 the vapor inlet port of the condenser; and
14 a liquid transport line operatively coupling the liquid output port of the condenser to
15 the liquid inlet port of the evaporator.

1 2. The CPL cooling system of claim 1, wherein the first wicking structure is disposed
2 within the cavity in the evaporator.

1 3. The CPL cooling system of claim 1, wherein the first condenser further includes in
2 internal cavity in which a volume of the working fluid is maintained in its liquid state,
3 thereby functioning as a reservoir in addition to a condenser.

1 4. The CPL cooling system of claim 1, further comprising a reservoir having an inlet
2 operatively coupled to the liquid outlet port of the first condenser via a first portion of the
3 liquid transport line and an outlet operatively coupled to the liquid inlet port of the evaporator
4 via a second portion of the liquid transport line.

1 5. The CPL cooling system of claim 1, wherein the first wicking structure comprises a
2 volume of a sintered material.

1 6. The CPL cooling system of claim 5, wherein the sintered material comprises a
2 sintered copper.

1 7. The CPL cooling system of claim 1, wherein the first wicking structure comprises a
2 piece of meshed material disposed within the evaporator.

1 8. The CPL cooling system of claim 1, further comprising:
2 a second evaporator adapted to be thermally coupled to a second semiconductor heat
3 source, including a cavity in which a working fluid is evaporated from a liquid state into a
4 vapor state and having a liquid inlet port to receive a portion of the working fluid in a liquid
5 state and a vapor outlet port from which a portion of the working fluid exits the evaporator in
6 a vapor state;

7 a second wicking structure, having an input side to receive the working fluid in a
8 liquid state and including a plurality of capillary channels to draw the working fluid into the
9 evaporator through a capillary transport mechanism;

10 a vapor transport line connection segment operatively coupling the vapor outlet port
11 of the second evaporator to the vapor transport line; and

12 a liquid transport line connection segment operatively coupling the liquid inlet port of
13 the second evaporator to the liquid transport line.

1 9. The CPL cooling system of claim 1, further comprising a heatsink thermally coupled
2 to the condenser.

1 10. The CPL cooling system of claim 9, further comprising a fan disposed relative to the
2 heatsink so as to draw air across the heatsink when the fan is operated.

1 11. The CPL cooling system of claim 1, wherein the working fluid comprise water.

1 12. The CPL cooling system of claim 1, further comprising:
2 a second condenser to condense a portion of the working fluid from a vapor state into
3 a liquid state, having a vapor inlet port to receive the working fluid in its vapor state and a
4 liquid outlet port from which the working fluid exits the condenser in its liquid state;
5 a vapor transport line connection segment operatively coupling the vapor inlet port of
6 the second condenser to the vapor transport line; ; and
7 a liquid transport line connection segment operatively coupling the liquid output port
8 of the second condenser to the liquid transport line.

1 13. The CPL cooling system of claim 1, wherein at least a portion of each of the liquid
2 transport line and the vapor transport line is flexible.

1 14. The CPL cooling system of claim 1, wherein the components of the cooling system
2 are configured to operate in a computer server having a 1U form factor.

1 15. A condenser, comprising:
2 a single coil of tubing having a helical configuration and including an inlet port to
3 receive a working fluid in a vapor state and an outlet port from which the working fluid exits
4 the condenser in a liquid state; and

5 a plurality of fins disposed about a centerline of the single coil of tubing.

1 16. The condenser of claim 15, further comprising a low-profile centrifugal fan disposed
2 within the single coil of tubing and operatively coupled to the single coil of tubing, said low-
3 profile centrifugal fan including a motor coupled to a fan rotor comprising a plurality of fan
4 blades that when rotated by the motor cause air to flow over the plurality of fins to assist in
5 removing heat from the condenser.

1 18. A thin-profile condenser, comprising:
2 a cover plate;
3 a channeled base member having an external wall extending around a periphery
4 thereof to which the cover plate is secured so as to define a sealed cavity, and further
5 including at least one internal wall including a portion disposed substantially adjacent to a
6 portion of the external wall so as to define a capillary channel, said at least one internal wall
7 dividing the sealed cavity into a condensing region and the capillary channel;
8 an vapor inlet port to receive a working fluid in a vapor state operatively coupled to
9 the sealed cavity; and
10 a first liquid outlet port from which the working fluid exits the condenser, operatively
11 coupled to an outlet end of the capillary channel.

1 19. The thin-profile condenser of claim 18, further comprising a charge port operatively
2 coupled to the condenser to enable the condenser to be charged with the working fluid.

1 18. The thin-profile condenser of claim 18, further comprising a hole extending through
2 the condensing region.

1 19. The thin-profile condenser of claim 18, wherein said at least one internal wall
2 includes wall portions that are configured so as to thermally isolate the capillary channel from
3 the condensing region.

1 20. The thin-profile condenser of claim 18, wherein said at least one internal wall
2 includes portions that are configured symmetrically so as to form a centrally-disposed
3 condensing region connected to a first capillary channel disposed on a first side of the
4 condensing region and a second capillary channel disposed on a second side of the
5 condensing region opposite of the first side.

1 21. The thin-profile condenser of claim 20, further comprising a second liquid outlet port
2 operatively coupled to an outlet end of the second capillary channel.

1 22. The thin-profile condenser of claim 18, further comprising a plurality of post disposed
2 within the condensing region extending between the channeled base member and the cover
3 plate.

1 23. The thin-profile condenser of claim 18, further comprising a heatsink thermally
2 coupled to the cover plate.

1 24. The thin-profile condenser of claim 23, wherein the heatsink comprises a base plate
2 having a plurality of pins extending upward therefrom.

1 25. The thin-profile condenser of claim 23, further comprising a centrifugal fan including
2 an annular fan rotor having a plurality of fan blades disposed around a periphery of the
3 heatsink so as to draw air across the heatsink when rotated.

1 26. An evaporator, comprising
2 a base in which a cavity is defined within a peripheral portion thereof and configured
3 to be thermally coupled to a semiconductor heat source;
4 a top cover secured to the peripheral portion of the base so as to define a sealed
5 volume in which a working fluid is vaporized;
6 a liquid inlet port to receive the working fluid in a liquid state, operatively coupled to
7 the sealed volume;
8 a vapor liquid inlet port from which the working fluid exits the evaporator in a vapor
9 state, operatively coupled to the sealed volume; and
10 a wicking structure, disposed within a portion of the cavity, having a top surface on
11 which a meniscus of the working fluid is formed and a bottom surface into which the
12 working fluid is drawn through a capillary mechanism and a pressure differential between a
13 pressure of the working fluid in the meniscus and a pressure of vaporized working fluid in the
14 sealed volume.

1 27. The evaporator of claim 26, further comprising a plurality of structural elements
2 extending between the base and the top cover so as to prevent the sealed volume from
3 collapsing when the evaporator is operated such that evaporation of the working fluid occurs
4 under sub-atmospheric conditions.

1 28. The evaporator of claim 26, wherein the wicking structure comprises a volume of a
2 sintered material.

1 29. The evaporator of claim 27, wherein the sintered material comprises a sintered
2 copper.

- 1 30. The evaporator of claim 27, wherein each of the base and the top cover comprise
- 2 stamped metal components.